

WHAT IS CLAIMED IS:

1. A digital data play back apparatus comprising:  
conversion means for converting a signal read from  
a recording medium into digital data by sampling the  
5 signal in a clock frequency output from a variable  
frequency oscillation means;

equalizing means for equalizing digital data  
output from this conversion means into a waveform which  
agrees with a partial response class on the basis of a  
10 clock output from a variable frequency oscillation  
means;

data detection means for detecting data on the  
basis of a clock output from the variable frequency  
oscillation means with respect to the signal waveform  
15 output from this equalizing means;

timing phase gradient detection means for  
detecting a timing phase gradient between a signal  
waveform output from the equalization means and a clock  
output from the variable frequency oscillation means;  
20 and

control means for controlling the oscillation  
frequency of the variable frequency oscillation means  
on the basis of the timing phase gradient detected with  
the timing phase gradient detection means.

25 2. The data play back apparatus according to  
claim 1, wherein the timing phase gradient detection  
means comprises:

addition means for adding an amplitude value of the signal waveform output from the equalizing means at two sample points which continues in time;

prediction means for predicting the amplitude  
5 value in the case where the signal waveform output from the equalizing means is phase synchronized with the clock output from the variable frequency oscillation means on the basis of the addition result obtained with this addition means; and

10 detection means for detecting the timing phase gradient on the basis of the amplitude value predicted with the prediction means and the signal waveform output from the equalizing means.

3. The data play back apparatus according to  
15 claim 1, wherein the timing phase gradient detection means comprises:

addition means for adding an amplitude value of the signal waveform output from the equalizing means at two sample points which continues in time;

20 prediction means for predicting the direction of change of the amplitude in the case where the signal waveform output from the equalizing means is phase synchronized with the clock output from the variable frequency oscillation means on the basis of the  
25 addition result obtained with this addition means; and

detection means for detecting the timing phase gradient on the basis of the direction of change in the

amplitude value predicted with the prediction means and the signal waveform output from the equalizing means.

4. The digital data play back apparatus according to claim 1, wherein the timing phase gradient detection means comprises:

prediction means for predicting an amplitude value in the case where the signal waveform output from the equalizing means is phase synchronized with a clock generated from the variable frequency oscillation means;

recording means for recording the history of the amplitude value predicted with the prediction means;

calculation means for calculating the timing phase gradient in a plurality of sample points of the signal waveform output from the equalizing means on the basis of the amplitude value predicted with the prediction means and the history of the amplitude value recorded on the recording means; and

selection means for selecting an output of the calculation means on the basis of the amplitude value predicted with the prediction means and the history of the amplitude value recorded on the recording means.

5. The digital data play back apparatus according to claim 1, wherein the timing phase gradient detection means comprises:

judgment means for judging which of the plurality of the reference values of the waveform after

equalization the level of the amplitude of the signal output from the equalizing means belongs to;

recording means for recording the history of the judgment result of the judgment means;

5 calculation means for calculating the timing phase gradient at the plurality of sample points of the signal waveform output from the equalizing means on the basis of the judgment result of the judgment means and the history of the amplitude recorded on the recording means; and

selection means for selecting an output of the calculation means on the basis of the judgment result of the judgment means and the history of the amplitude value recorded on the recording means.

15 6. The digital data play back apparatus according to claim 1, wherein the timing phase gradient detection means comprises:

prediction means for predicting the amplitude value in the case where the signal waveform output from the equalizing means is phase synchronized with the clock output from the variable frequency oscillation means;

recording means for recording the history of the amplitude value predicted with the prediction means;

25 judgment control means for judging that a plurality of sample point rows of the signal waveform output from the equalizing means on the basis of the

amplitude value predicted with the prediction means and the history of the amplitude value recorded on the recording means are sample point rows in the case where a pit or a mark on a recording medium is read, wherein  
5 a continuous first value for at least (a partial response class interference length-1) clock portion and a second value for at least (a partial response class interference length-1) clock portion are formed with adjacent writing current pattern; and

10 calculation means for calculating a timing phase gradient from a plurality of sample times of the signal waveform output from the equalizing means on the basis of the amplitude value predicted with the prediction means and the history of the amplitude value recorded  
15 with the recording means in accordance with the judgment result with the judgment control means.

7. The digital data play back apparatus according to claim 1, wherein the timing phase gradient detection means comprises:

20 judgment means for judging which of the plurality of reference values of the waveform after equalization the level of the amplitude value of the signal output from the equalizing means belongs to;

recording means for recording the history of the  
25 judgment result of the judgment means; and

judgment control means for judging that a plurality of sample points of the signal waveform

output from the equalizing means on the basis of the judgment result of the judgment means and the history of the amplitude value recorded with the recording means are sample points in the case where a pit or a mark on a recording medium is read, wherein a

5 continuous first value for at least (a partial response class interference length-1) clock portion and a second value for at least (a partial response class interference length-1) clock portion are formed with adjacent writing current pattern; and

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calculation means for calculating a timing phase gradient from a plurality of sample times of the signal waveform output from the equalizing means on the basis of the judgment result of the judgment means and the history of the amplitude value recorded with the recording means in accordance with the judgment result with the judgment control means.

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8. A method for playing back digital data comprising:

20 a first step of converting a signal read from the recording medium into digital data by sampling the signal in a clock frequency output from a variable frequency oscillation means;

a second step of equalizing the digital data output at the first step into a waveform which agrees with a partial response class on the basis of a clock output from the variable frequency oscillation means;

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a third step of detecting data on the basis of the clock output from the variable frequency oscillation means with respect to the signal waveform output at the second step

5 a fourth step of detecting a timing phase gradient between a signal waveform output at the second step and a clock output from the variable frequency oscillation means; and

10 a fifth step of controlling the oscillation frequency of the variable frequency oscillation means on the basis of the timing phase gradient detected at the fourth step.

9. The digital data play back method according to claim 8, wherein the fourth step comprises:

15 an addition step of adding an amplitude value of the signal waveform output at the second step at two sample points which continues in time;

a prediction step of predicting an amplitude value in the case where the signal waveform output at the  
20 second step is phase synchronized with the clock output from the variable frequency oscillation means on the basis of the addition result obtain at the addition step; and

25 a detection step of detecting the timing phase gradient on the basis of the amplitude value predicted with this prediction step and the signal waveform output at the second step.

10. The digital data play back method according to claim 8, wherein the fourth step comprises:

an addition step of adding an amplitude value of the signal waveform output at the second step at two  
5 sample points which continues in time;

a prediction step of predicting a direction of change in the amplitude value in the case where the signal waveform output at the second step is phase synchronized with the clock output from the variable  
10 frequency oscillation means on the basis of the addition result obtained at the addition step; and

a detection step of detecting a timing phase gradient on the basis of the direction of change in the amplitude value predicted with this prediction step and the signal waveform output at the second step.  
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11. The digital data play back method according to claim 8, wherein the fourth step comprises:

a prediction step of predicting an amplitude value in the case where the signal waveform output at the second step is phase synchronized with the clock output from the variable frequency oscillation means;  
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a recording step of recording the history of the amplitude value predicted at the prediction step;

a calculation step of calculating the timing phase gradient at the plurality of sample points of the signal waveform output at the second step on the basis of the amplitude value predicted at the prediction step  
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and the history of the amplitude value recorded at the recording step; and

5 a selection step of selecting an output of the calculation step on the basis of the amplitude value predicted at the prediction step and the history of the amplitude value recorded at the recording step.

12. The digital data play back method according to claim 8, wherein the fourth step comprises:

10 a judgment step of judging which of the plurality of the reference values of the waveform after equalization the level of amplitude value of the signal output at the second step belongs to;

a recording step of recording the history of the judgment result at this judgment step;

15 a calculation step of calculating the timing phase gradient at the plurality of sample points of the signal waveform output at the second step on the basis of the judgment result at the judgment step and the history of the amplitude value recorded at the recording step; and

20 a selection step of selecting an output of the calculation step on the basis of the judgment result of the judgment step and the history of the amplitude value recorded at the recording step.

25 13. The digital data play back method according to claim 8, wherein the fourth step comprises:

a prediction step of predicting the amplitude

value in the case where the signal waveform output at the second step is phase synchronized with the clock output from the variable frequency oscillation means;

5 a recording step of recording the history of the amplitude value predicted at this prediction step;

10 a judgment control step of judging that a plurality of sample point rows of the signal waveform output at the second step on the basis of the amplitude value predicted at the prediction step and the history of the amplitude value recorded at the recording step are a sample point row in the case where a pit or a mark on a recording medium is read, wherein a continuous first value for at least (a partial response class interference length-1) clock portion and a second value for at least (a partial response class interference length-1) clock portion are formed with adjacent writing current pattern; and

15 a calculation step of calculating the timing phase gradient from a plurality of sample times of the signal waveform output from the second step on the basis of the amplitude value predicted at the prediction step and the history of the amplitude value recorded at the recording step in accordance with the judgment result at the judgment control step.

20 14. The digital data play back method according to claim 8, wherein the fourth step comprises:

a judgment step of judging which of the plurality

of the reference values of the waveform after equalization the level of the amplitude value of the signal output at the second step belongs to;

5 a recording step for recording the history of the judgment result at the judgment step;

10 a judgment control step for judging that a plurality of sample point rows of the signal waveform output at the second step on the basis of the judgment result at the judgment step and the history of the amplitude value recorded at the recording step are a sample point row in the case where a pit or a mark on a recording medium is read, wherein a continuous first value for at least (a partial response class interference length-1) clock portion and a second value  
15 for at least (a partial response class interference length-1) clock portion are formed with adjacent writing current pattern; and

20 a calculation step of calculating the timing phase gradient from a plurality of sample times of the signal waveform output at the second step on the basis of the judgment result at the judgment step and the history of the amplitude value recorded at the recording step in accordance with the judgment result at the judgment control step.